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## CONSERVATION OF THE EVERGLADES

by Herman W. Schull, Jr.

IRRIGATION AND DRAINAGE
DIVISION

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# CONSERVATION OF THE EVERGLADES

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Fellow Americans, it has been a pleasure for me to attend this stimulating convention. My contribution is to discuss a major engineering project for the conservation of the Everglades in southern Florida. The objective of this project is water control in a vast agricultural area which is subject to disastrous flooding after heavy rainfall and destructive droughts in dry seasons. This flooding is frequently caused by tropical cyclonic storms which originate mostly in the southern North Atlantic Ocean. We in Florida have common bond of interest with you in Puerto Rico. These storms are common occurrences in our countries.

General Description

I can best describe the Everglades area from this map of southern Florida. In its original state, this region south of Lake Okeechobee was a solitude of sawgrass and water, some 40 miles wide and 100 miles in length from the lake to the sea at the southern end of Florida. At the upper end of this area is Lake Okeechobee, over 700 square miles in area, which is the third largest lake in the United States. The main source of water supply other than rain falling directly on the lake is the Kissimmee River, which has a drainage area of 3,200 square miles.

Under natural conditions, the waters of Lake Okeechobee in the wet season used to rise over the southern rim of the lake and push through a dense growth of custard apple and move slowly southward through the sawgrass marsh of the Everglades. These waters would mingle with the fallen rain standing on the flat expanse of the Everglades and flow slowly through the grass and vegetation. The water would finally escape eastward through a few small rivers which flowed through the east coast barrier ridge, or pass eventually to the sea through the tangled mangrove thickets which mark the southern tip of the Florida peninsula.

This Everglades marsh lies in a trough of sedimentary limerock, and is bordered on the east by a narrow coastal ridge which attains elevations up to 13 feet above sea level. On the west the Everglades are bounded by sand hills which rise to an elevation of 25 feet. The continuous growth and decay of sawgrass and other vegetation over long periods of geologic time have produced throughout the area south of Lake Okeechobee an extensive deposit of organic muck and peat which now composes the soil of the Everglades. The muck land constitutes the largest deposit of organic soil which has been discovered anywhere in the world. The elevation of the muck lands averages 17 feet above sea level at Lake Okeechobee and slopes down to about 6 feet above sea level opposite Miami. The depth of the muck soil is about 12 feet in the vicinity of Lake Okeechobee and is less than 1 foot west of Miami.

When properly drained and protected from flooding, muck lands are capable of high agricultural production. Vegetables, sugarcane, ramie, citrus, and cattle are among the valuable products of this fertile land. However, farming

in the flat muck lands of the Everglades is suggessful only when a favorable groundwater elevation is maintained during the growing season. Under favorable conditions, two or three successive crops can be produced during the winter season. At the present time, about one-third of the 1,000 square miles of arable land has been developed for agriculture. The development of the remainder is dependent on providing a comprehensive plan of water control.

Water Control Problems

Although the soil of the area is rich and can be made extremely productive by the addition of fertilizers, it is constantly harassed with too much water during the summer months and not enough water during the winter. During the wet season, June through October, water-control pumps must be in action almost constantly removing excess run-off from the cultivated areas. During the dry season, November through May, the pumps are reversed and water is supplied to the growing crops from the main canals. Lake Okeechobee serves as a reservoir for these canals. The lake has two major outlets, the St. Lucie and Caloosahatchee Canals, which give reasonable control of water-surface elevations in the lake.

Water is stored during periods of heavy rainfall and withdrawn during the growing season and during periods of drought. To fully develop the area for agriculture and realize its capabilities, the water levels must be maintained about 18 inches below the ground surface. Rainfall has to be removed from certain crops almost as fast as it falls. Adequate ground-water control must be available for growing crops which include sugarcane, ramie, kenaf, or tender truck crops and pasture.

The rainfall of this area is about 54 inches annually, while the evaporation is about 44 inches annually. About 70 percent of the rainfall occurs during the months of June through October. However, rainfall up to 4 inches may occur any day during the year. The flat topography, the heavy vegetation and absorptive nature of the soil combine to produce very slow runoff.

During the past 50 years the drainage pattern of the Everglades has been greatly altered by the construction of canals and levees. Four major canals were excavated from Lake Okeechobee leading to the Atlantic Ocean between Miami and Palm Beach. Levees were built around the southern shore of Lake Okeechobee, and the St. Lucie River on the east and the Caloosahatchee on the west were canalized and connected to the lake by locks and dams. The system of development thus provided was inadequate. Hurricanes in this region have been very destructive. Under the force of hurricane winds the water has been raised high along the southern shore of Lake Okeechobee. The early levees were overtopped by wave action and on several occasions just melted away. Hurricane driven waters from the Everglades have swept into the densely populated cities on the east coast.

Some of you may recall the devastation caused by the 1947 hurricane. That hurricane came near the close of a record-breaking wet year when the land was thoroughly saturated. Torrential rains fell on the Kissimmee Valley and over the Everglades. Flood waters with no place to drain off caused widespread loss of cattle and wild life and property damage over a great portion of southern Florida. More than fifty million dollars worth of flood damages were caused that year. The attention of the people of the United States were focused on the flood problems of southern Florida. The Corps of Engineers were directed to prepare a comprehensive plan of flood protection and water control which would consider all aspects of conservation.

Comprehensive Plan of Development

This plan has been presented to Congress and published as House Document 643, 80th Congress. It provides water control for a most extensive area of 15,000 square miles: The Everglades south of Lake Okeechobee, the Kissimmee and upper St. Johns basins to the north, and the east coast of southern Florida. The cost of engineering and construction will be more than 200 million dollars. These costs are being shared jointly by the Federal Government and the State of Florida in proportion to the benefits received from the improvement. The distribution of costs is 61 percent to the Federal Government and 39 percent to the State.

The plan for the Everglades, which I will discuss in some detail, provides a perimeter levee inclosing the richest mucklands south of the lake, which is an area of about 1,000 square miles. The enlargement of four existing canals are provided: The West Palm Beach, the Hillsboro, North New River and the Miami. These canals are designed in general to remove flood waters from the northern part of the area into Lake Okeechobee, and from the southern part of the area into three conservation areas. These conservation areas are extensive and are located on low lands which are not suitable for any agricultural production. The canals and the pump stations are designed and sized to remove three-fourths of an inch of runoff per 24 hours. The conservation areas will be encircled by large levees to prevent overflow of water to surrounding areas. The surplus water stored in such areas will be available for irrigation and domestic water supply for the urban areas on the east coast.

In addition to the Federal improvements, local land owners must provide their own lateral canals and pump stations to remove, or add water to their respective agricultural areas. Successful agriculture requires dikes to inclose all areas under cultivation and canals with pumping capacity to remove surplus water. Gravity flow can not generally be depended upon.

The main canals and pump stations in the Corps of Engineers' plan of improvement do not have the capacity for removing rainwater as fast as it falls. Some lands with perishable crops might have to be pumped at the rate of 6 inches per day. This high pumping rate would be balanced by a low rate on other lands. Some crops such as pasture can tolerate standing water for several weeks. Other crops such as vegetables can be destroyed by water in a few days. Since there is considerable diversification of crops in the protected area, it was determined that sufficient capacity for removal of three-fourths of an inch of water in 24 hours for the entire area would be satisfactory. The canals in the entire area would be provided with low levees to prevent overflow back on the agricultural lands. The large storage in the canals above normal elevation will provide considerable extra storage for increased pumping of water.

The First Phase Plan

The comprehensive plan is an enormous undertaking that will take many years to complete. The features of work which will provide the greatest benefit have been placed in top priority for construction in the first phase. The first phase of the project will be undertaken first and is estimated to cost $111,698,000. It consists of about 100 separate items: canals, levees, spillways, and pumping stations on the East Coast and in the Everglades. The items shown on this map in green are in this first phase, and so are items in blue, which are under construction, and in red which have been completed. The items selected for this first phase protect existing urban areas and presently developed major food producing areas.

Since the most intensively developed mucklands of the Everglades lie just south of the lake, the First Phase Plan includes a series of levees encircling that area and a system of interior canals for flood drainage and for irrigation. Pump stations are located at the north end of the Miami and North New River canals for discharge into Lake Okeechobee. Other pump stations are located at the south end of the West Palm Beach and Hillsboro canals for discharge into the conservation areas. These pump stations are notable from the point of view of their high discharge capacity.

Station No. 5A now under construction will have a total capacity of 4,600 cubic feet per second and will consist of six horizontal pumps, 106 inches in diameter, 800 cubic feet per second capacity at 11.1 ft. static head. The best efficiency point is at about 9.2 ft., the average head. The impeller speed is about 125 rpm. The pumps will be driven by 1,600 brake horsepower inline Diesel engines at a speed of 720 rpm. through double-reduction silent chain drives.

The First Phase also includes a series of levees along the eastern edge of the conservation areas, which are to complete the inclosure of these areas and also to provide protection for the east coast cities and agricultural area. There is also included as a part of the First Phase a system of canals, spillways, pump stations and salt intrusion barriers for the protection of the East Coast area. These works are not in the Everglades and will not be discussed further in this paper.

The system of flood protection for the Everglades is designed to safely pass the critical run-off of record with the minimum of damage. The storm causing this critical run-off will probably occur at the end of the rainy season, after a prolonged period of rainfall has saturated the ground and filled all available storage areas in the watershed.

Plate No. 2 shows the distribution of flow in the project flood for which the system of protection has been designed. The width of the arrows indicate the volume of water entering or discharged from the lake into the agricultural area and conservation areas.

During this critical run-off, the Kissimmee River discharges a total of 3,800,000 acre-feet into Lake Okeechobee. In addition, 2,400,000 acre-feet will fall directly on the lake in addition to the other local inflow. The normal conservation pool of the lake is at elevation 15.3 feet. During the project flood, the lake will rise to 20.9 feet. As can be seen from the map, 4,500,000 acre-feet (or 53 percent) will be discharged through the St. Lucie Canal. 1,900,000 acre-feet (or 22 percent) will be discharged down the Caloosahatchee River Canal. About 10 percent will be passed off as evaporation, and about 15 percent will be discharged jointly through the West Palm Beach and Hillsboro Canals to the conservation areas.

For the 12 years of record (1938 through 1949) the flow distribution is shown on plate 3. It has been necessary to use a different scale on plate 3 than that shown on plate 2 because the flows are so much larger. It should be noted that 9,100,000 acre-feet was discharged from the Kissimmee River and that 26,100,000 acre-feet fell directly on the lake. During the 12 years, evaporation accounted for 48 percent of the flow; irrigation 7.3 percent; discharge through the West Palm Beach and Hillsboro Canals to the conservation areas 15.2 percent; discharge through the St. Lucie Canal 19.6 percent; and discharge through the Caloosahatchee River Canal 10 percent. The most significant point in the flow distribution during the 12 years of record is that evaporation takes nearly 50 percent of the available water supply, whereas irrigation from the lake accounts for only a little over 7 percent. It is true that some of the water which is discharged through the conservation areas

is utilized for irrigation purposes along the coast. However, only about 10 percent of the water that was available in the lake during the 12 years of record could have utilized for useful purposes.

Benefits of the Project

The four major canals will provide adequate water control throughout the year. The flood protection and water control afforded by the proposed improvements will result in large benefits from the prevention of flood damages and the increased use of land. In addition, the project will produce other substantial benefits for navigation, preservation of fish and wildlife, improved water supply, reduction of salt-water intrusion in coastal areas, and better sanitary conditions. Estimates of flood damages which will be prevented by the proposed improvements have been based on all records of past floods and flood losses. Flood losses in the hurricane of 1947 were heavy and wide-spread. The loss to sugar cane planters alone around Lake Okeechobee was estimated at $1,450,000, and cattle raisers suffered damages of over $3,400,000. In addition, many miles of highways were damaged with the resulting dislocation of transportation facilities and large costs for rebuilding and resurfacing. In the Lake Okeechobee-Everglades area alone, the total average annual damages amount to $4,130,000. The total average annual benefits due to increased land use and by virtue of flood protection and other considerations will amount to $13,922,000.

In the Everglades-East Coast area the average annual flood damages which will be prevented by the proposed improvements, are estimated at $10,812,000. The average annual benefits from this project are much greater than the damages prevented due to the enhancement of land values when flood protection is provided. The average annual value of the land enhancement is estimated at $24,491,000. The total annual benefits including benefits to fish and wild life, amount to $35,493,000. The total annual charges are estimated at $11,616,000.

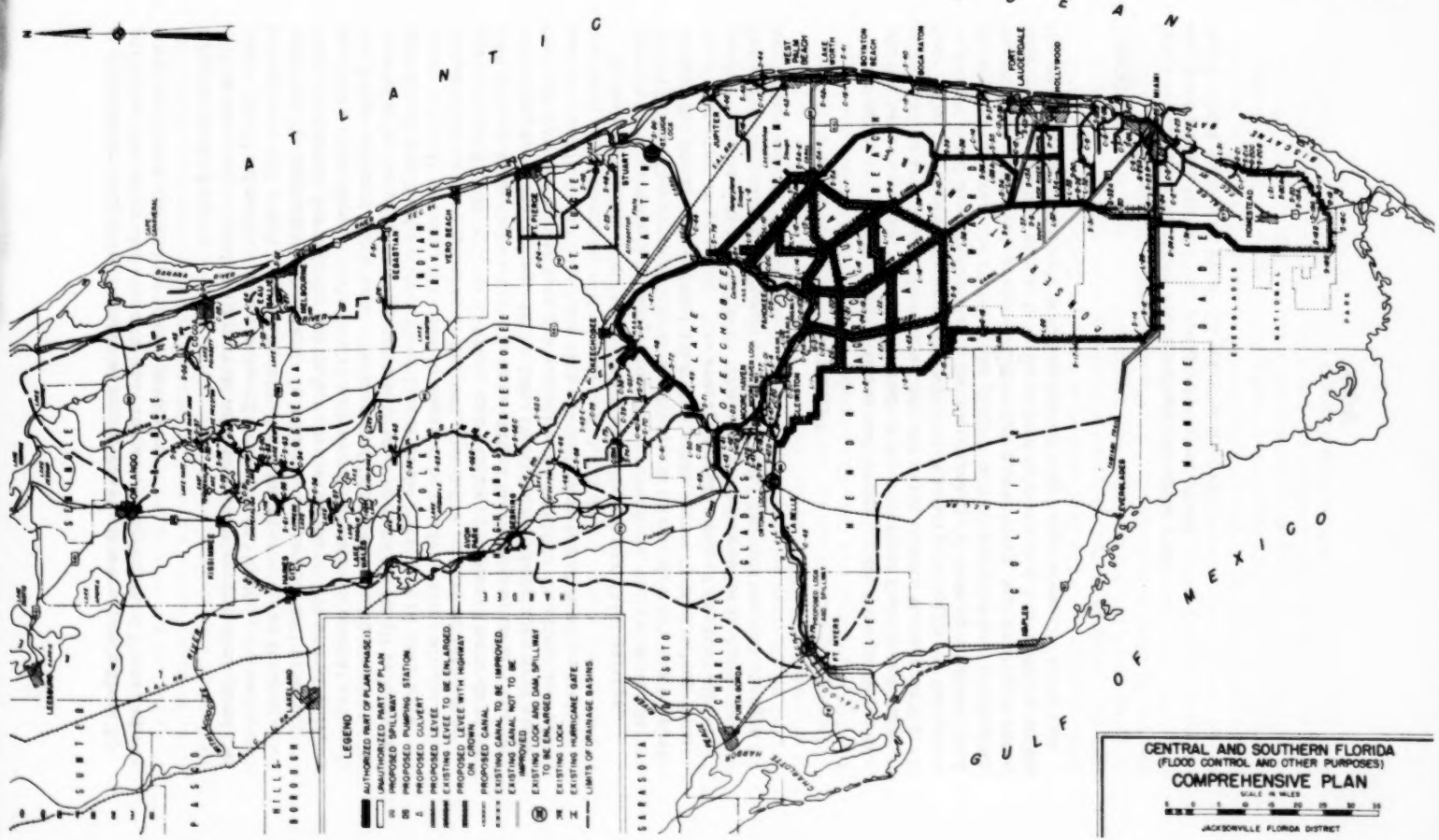
## SUMMARY

The system of canals, pump stations and levees for the Everglades area which I have described will greatly reduce the enormous flood losses sustained in this area and will provide adequate water control throughout the year. The improvements proposed will result in large benefits for the prevention of flood damages and from the increased yield from agricultural land throughout the area. In addition, the project will produce further substantial benefits for navigation, preservation of fish and wildlife, and improved water supply. The Ratio of annual benefits to cost is more than 3 to 1, which makes the project overwhelmingly justified from a long range economic viewpoint.

## CHARTS

No. 1 - Central & Southern Florida Comprehensive Plan
No. 2 - Distribution of Flow, Standard Project Flood
No. 3 - Distribution of Flow, 12 years of Record

CHART No. I


ATLANTIC OCEAN
GULF OF MEXICO
LEGEND
AUTHORIZED PART OF PLAN (PHASE I)
UNAUTHORIZED PART OF PLAN
PROPOSED SPILLWAY
PROPOSED PUMPING STATION
PROPOSED CULVERT
PROPOSED LEVEE
EXISTING LEVEE TO BE ENLARGED
PROPOSED LEVEE WITH HIGHWAY ON CROWN
PROPOSED CANAL
EXISTING CANAL TO BE IMPROVED
EXISTING CANAL NOT TO BE IMPROVED
EXISTING LOCK AND DAM, SPILLWAY TO BE ENLARGED
EXISTING LOCK
EXISTING HURRICANE GATE
LIMITS OF DRAINAGE BASINS
CENTRAL AND SOUTHERN FLORIDA
(FLOOD CONTROL AND OTHER PURPOSES)
COMPREHENSIVE PLAN
SCALE IN MILES
JACKSONVILLE FLORIDA DISTRICT

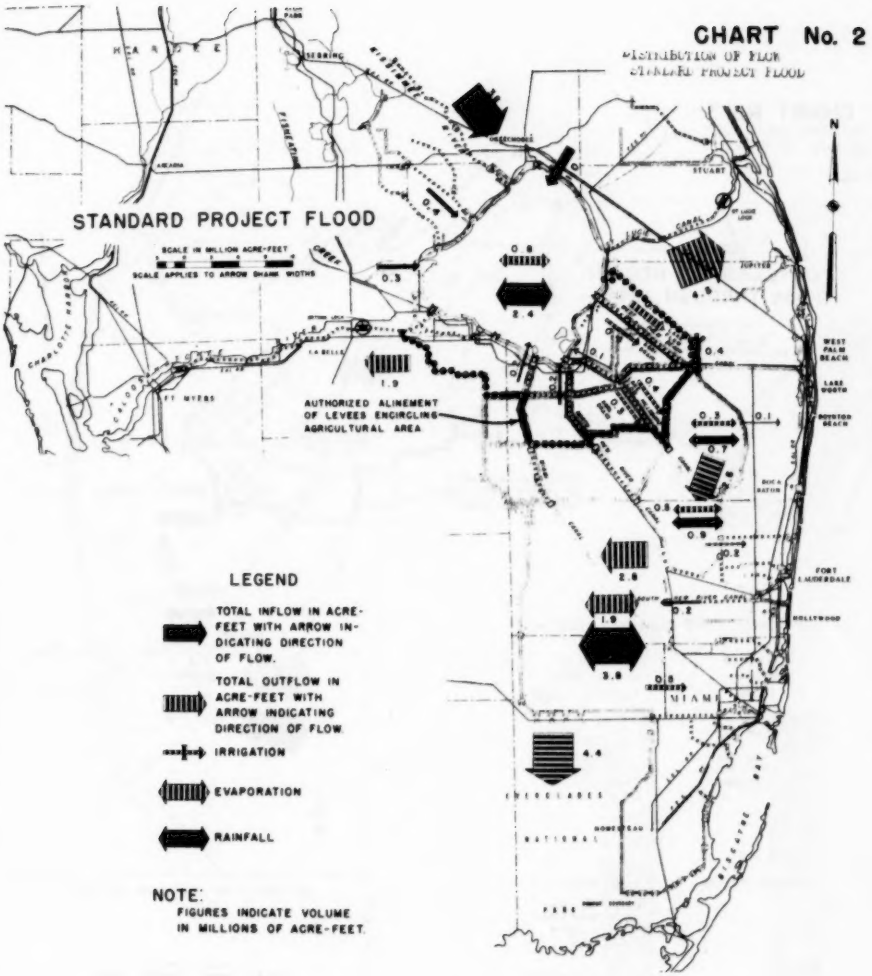
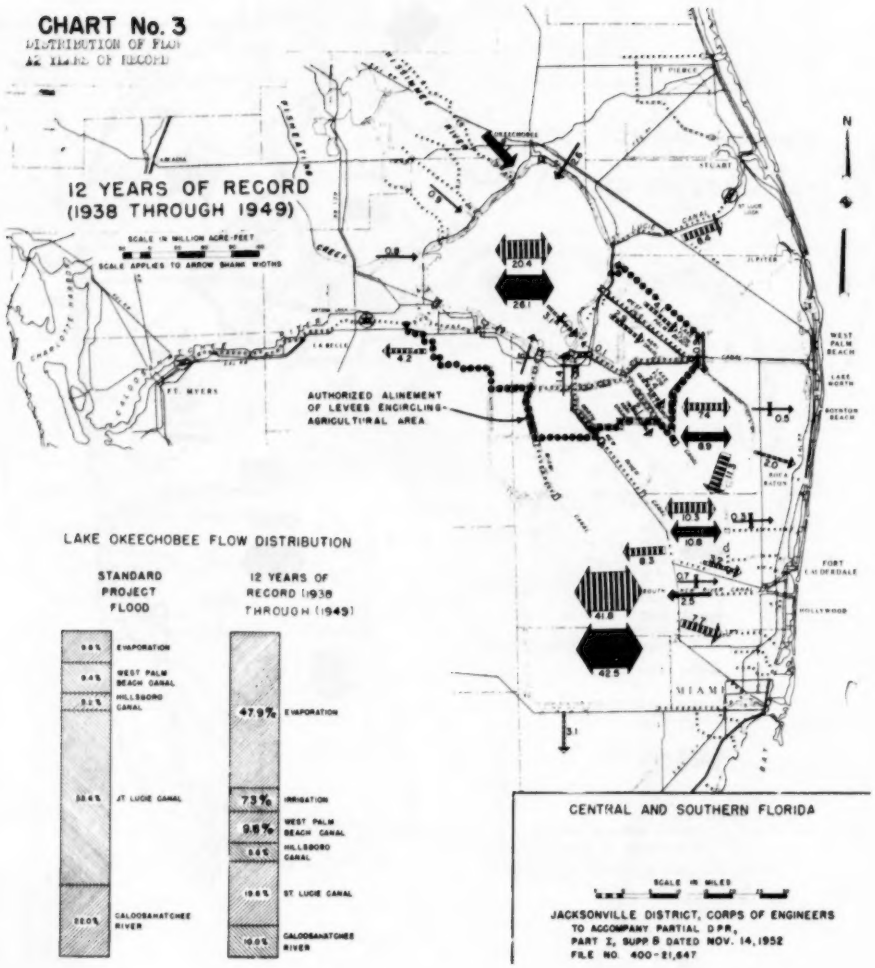


CHART No. 2
DISTRIBUTION OF FLOW
STANDARD PROJECT FLOOD
STANDARD PROJECT FLOOD
SCALE IN MILLION ACRE-FEET
SCALE APPLIES TO ARROW SHANK WIDTHS
AUTHORIZED ALINEMENT OF LEVEES ENCIRCLING AGRICULTURAL AREA
LEGEND
TOTAL INFLOW IN ACRE-FEET WITH ARROW INDICATING DIRECTION OF FLOW.
TOTAL OUTFLOW IN ACRE-FEET WITH ARROW INDICATING DIRECTION OF FLOW
IRRIGATION
EVAPORATION
RAINFALL
NOTE:
FIGURES INDICATE VOLUME IN MILLIONS OF ACRE-FEET.
N
MIAMI
STUART
JUPITER
WEST PALM BEACH
LAKE WORTH
BOYNTON BEACH
FORT LAUDERDALE
HOLLYWOOD
EVERGLADES
NATIONAL
PARK
0.8
2.4
0.3
1.9
4.9
0.4
0.1
0.7
0.9
0.2
2.8
1.9
3.8
4.4

# CHART No. 3

DISTRIBUTION OF FLOW
AT YEARS OF RECORD



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